

# The National Science Foundation And the Life Sciences

By ALAN T. WATERMAN, Ph.D., Sc.D.

Describing the National Science Foundation as a Federal agency "independent of specialized missions, yet having an interest in common with other Federal agencies in the progress of science and the national welfare," its director outlines its functions, organization, and programs, with particular reference to the medical and biological sciences. In so doing, he indicates trends in the philosophy of scientific research. A discussion of trends in support and expenditures for scientific research appeared in the February 1954 issue of *Public Health Reports*.

**M**EDICAL RESEARCH in the United States has increased substantially during the years since 1941, requiring an increasing number of medical scientists and larger expenditures of funds (1, 2). These increases in medical research, of course, are characteristic of the trends exhibited generally by scientific research and development activities in this country.

Also characteristic of the trends in scientific research, including medical research, is the en-

larged support given by the Federal Government. Expenditures of the Federal Government for scientific research and development have risen from \$97 million in fiscal year 1940 to \$2,187 million estimated for fiscal year 1954 (3). This rise in the Federal appropriation for research has resulted in a greater assumption of the total national expenditure for science by the Government. In fiscal year 1953, for example, the Federal Government expended \$2,205 million out of a total national scientific expenditure estimated at \$3,500 million.

With this increase in appropriations for scientific research and development, the Government has an added responsibility to insure that such funds are expended wisely, in the interests of both science and the national welfare. The Federal structure for the support, administration, and carrying out of scientific research and development is complex. There are at present some 24 Federal agencies involved in scientific research, each having a common effect in in-

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creasing the national research potential and in serving the national welfare, yet each motivated by special responsibilities related to specific missions assigned by the Congress or the President. Thus, the research which the Department of Defense administers or carries out in the medical sciences has much in common with the research of the Public Health Service, but defense agencies must plan and support research to fulfill special requirements in relation to national defense.

The areas of common interest among all Federal agencies involved in scientific research and development require that effective channels be developed for the interchange of scientific information and that unnecessary duplication be avoided. The special interests imposed by assigned missions require, furthermore, that some overall planning exist to insure a balanced Federal research program. For such purposes, it seems wise that an agency independent of specialized missions, yet having an interest in common with other agencies in the progress of science and the national welfare, serve as a center for studying the Federal participation in research and development. Such an agency is the National Science Foundation.

### **Basic Mission**

Established in 1950 as an independent organization on the policy level of Government, the National Science Foundation was authorized and directed by the Congress to fulfill the following basic mission:

1. Develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences.
2. Initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering, and other sciences.
3. At the request of the Secretary of Defense, initiate and support specific scientific research activities in connection with matters relating to the national defense.
4. Award scholarships and graduate fellowships in the mathematical, physical, medical, biological, engineering, and other sciences.
5. Foster the interchange of scientific information among scientists in the United States and foreign countries.

6. Evaluate scientific research programs undertaken by agencies of the Federal Government, and correlate the Foundation's scientific research programs with those undertaken by individuals and by public and private research groups.

7. Establish such special commissions as the National Science Board may from time to time deem necessary.

8. Maintain a register of scientific and technical personnel.

These are broad responsibilities. Principal functions of the Foundation may be divided into three categories: (a) the encouragement and support of basic research, (b) the training of future scientists, and (c) the development of national science policy, that is, the role the Federal Government should play with respect to science. Although each of these functions is related to the others, the first two may be thought of as the operating programs, and the last may be considered as the study or evaluation function of the Foundation.

### **Support of Basic Research**

The broad responsibilities of the Foundation, of course, have a specific relation to the life sciences, which include the biological, medical, and agricultural sciences. As an operating agency, the Foundation awards grants and makes contracts for the conduct of biological and medical research and awards graduate and postgraduate fellowships in those areas.

#### *Grants and Contracts*

Grants and contracts for basic research in the life sciences are administered by the division of biological and medical sciences of the Foundation. In general, proposals for research in the life sciences originate with the scientists and are selected with the help of scientific consultants who serve on advisory panels to the Foundation. Selections are based primarily on scientific merit. Other criteria involved in the review of proposals are the scientific ability of the project personnel, the relation of the proposal to contemporary research in the field, the scientific resources of the institution, the reasonableness of the budget, and the merit of the proposals in relation to others received by the

Foundation in related fields of science. In short, each investigator who submits a proposal to the Foundation may feel that it has been fairly considered by a competent group of his own colleagues.

The review procedure resembles that of other Federal agencies making grants or contracts for scientific research, but in two respects it does differ. The differences are the result of the general basic research mission of the Foundation and the functional breakdown of the Foundation's biological and medical research support programs.

#### *"Free" Research*

In its program for the support of basic research, the Foundation is free from the limitations imposed upon other agencies by their assigned mission. The interests of the Foundation in basic research are the promotion of science and the strengthening of basic research and education in the sciences. Such a broad interest allows the Foundation and its consultants to select research proposals without consideration of practical requirements of specific goals. Such "free" research is vital to the progress of science and the future of the Nation. Other Government agencies support basic research projects—and such support is a valuable part of all Government research programs—but their selection of proposals must necessarily be justified in terms of their assigned mission, and their support programs, therefore, have a close relationship to their operational goals. The Foundation, by having a greater freedom of selection, is able to complement the research of other agencies by giving support in neglected fields and by contributing to the development of a balanced Federal research program.

#### *Functional Organization*

The Foundation's program in the life sciences has been organized on a functional rather than on a disciplinary basis. In this way, the Foundation has regrouped research in the life sciences so that biological processes, whether in plant, animal, or man, will be seen in their basic contexts. Such a reorganization has the added advantage that interdisciplinary relationships in the life sciences may be more easily handled from both an administrative and a scientific in-

formation point of view. The Foundation's life science program is organized into the following categories:

*Developmental biology:* Asexual and sexual reproduction; maturation of germ cells; fertilization, growth, or reproduction of subcellular units; embryogenesis; histogenesis; organogenesis; general ontogeny; regeneration; adolescence; senescence.

*Environmental biology:* Gross effects of chemical, physical, and biological factors on the activities, distribution, and survival of organisms; biocommunities commensalism; symbiosis.

*Genetic biology:* Action and behavior of genes and chromosomes; nature and origin of inheritable characteristics and variations; effects of transformer substances; cytoplasmic inheritance; the "family history" of individuals and populations.

*Molecular biology:* The isolation, structural analysis, synthesis, and reactivity of biological substances; kinetics of biological reactions; diffusion.

*Psychobiology:* Physiological and psychological bases and correlates of the behavior of organisms at both human and subhuman levels.

*Regulatory biology:* Regulation of functional activities, including metabolism, respiration, circulation, digestion, absorption and assimilation, nervous and muscular activity, special senses, immunological responses, perspiration, translocation, transpiration, photosynthetic and metabolic plant processes, photoperiodism and phototropism, role and function of biocatalysts.

*Systematic biology:* Description of physical and functional characteristics; classification; meaning and integrity of species; "family history" and biological relationships of species, genera, and higher categories; life cycles; evolution.

The organization of the life sciences program of the Foundation is very similar to the classification advocated by Dr. Paul Weiss of the University of Chicago and chairman of the division of biology and agriculture of the National Research Council (4). Dr. Weiss points out

## National Science Foundation research grants in the biological and medical sciences

Categories	Fiscal 1952		Fiscal 1953		Fiscal 1954, first 2 quarters	
	Number of grants	Amount	Number of grants	Amount	Number of grants	Amount
Developmental biology -----	9	\$66, 975	4	\$39, 600	4	\$49, 900
Environmental biology -----	4	25, 060	2	7, 500	4	20, 300
Genetic biology -----	5	86, 800	7	100, 700	6	72, 100
Microbiology -----	9	83, 687	9	107, 600	(1)	(1)
Molecular biology -----	9	114, 500	11	134, 800	27	389, 500
Psychobiology -----	2	15, 400	8	101, 000	13	142, 350
Regulatory biology -----	15	173, 800	14	177, 900	29	369, 700
Systematic biology -----	11	106, 480	15	99, 700	16	122, 250
General -----	4	72, 760	2	30, 000	1	11, 500
<b>Total</b> -----	<b>68</b>	<b>745, 462</b>	<b>72</b>	<b>798, 800</b>	<b>100</b>	<b>1, 177, 600</b>

<sup>1</sup> Microbiology as a special category was reclassified into the other categories.

that "biology is in a state of flux" and that new concepts in research must be incorporated into our organization of the life sciences:

"Many of our traditional classifications were based on forms of life, as in bacteriology, botany, and zoology, or on methods of approach, as anatomy (for dissection) and biometrics (for measurement). With the growing realization of the general validity of certain basic principles common to all forms of life, a more natural organization of biology, according to inherent principles is gradually superseding the old pattern. Thus investigators and teachers have begun to draw promiscuously on bacteria, plants, animals, and man for knowledge and illustration of the principles of cell structure, metabolism, growth, heredity, excitation and coordination, adaptation, ecology, and evolution. Many of the greatest advances of biology have come in places where different specialties have combined forces in conjoint study. The spectacular development of genetics in this country has profited immensely from the correlation of facts from such diverse fields as cytology, animal and plant breeding, biochemistry, immunology, statistics, and taxonomy. As a result the old alinement gives way to a new, more natural and more consistent order."

### *1953 Program*

The National Science Foundation program in the life sciences is a modest one in relation to the total national effort in these areas. Dur-

ing fiscal year 1953, 72 grants totaling \$798,800 were made for support of basic research in the life sciences. In the previous year, 68 grants were made, totaling \$745,462. The average research grant for both years was for \$11,000 to run for 2 years, or about \$5,500 per year. The accompanying table gives a breakdown of the support given in the various areas of the life sciences for the 2 years by the Foundation.

The Foundation's support of basic research in the life sciences does not distinguish between the medical and biological sciences, since fundamental studies in both sciences are intimately related. The Foundation generally does not support clinical research, except that of a basic nature, nor does it make grants for studies of special diseases since such studies are supported by other Government and private groups.

### **Increasing Supply of Scientists**

The program of graduate and postgraduate fellowships in the sciences is designed to increase the national supply of trained scientists capable of undertaking basic research. Fellowships are awarded on the basis of ability only and are distributed among candidates of substantially equal ability on a geographic basis. The awards are distributed among scientific fields in proportion to the number of qualified applicants in each field.

A total of 557 fellowships was awarded for the academic year 1953-54 as compared with 624

for the previous year. Continuing the policy of emphasizing the first year of graduate study, the Foundation awarded 180 fellowships to first-year graduate students. A total of 166 awards was made to graduate students in the intermediate years; 169 to terminal year predoctoral students; and 42 to postdoctoral applicants.

Fellows are free to select any accredited institution of higher learning for their training. Stipends range from \$1,400 for the first-year graduate student to \$3,400 for postdoctoral study. Additional allowances for dependents, tuition, and other normal expenses are provided.

Out of a total of 1,004 applicants in the life sciences, 168 fellowships were granted. The distribution of fellowships by field was as follows: agriculture, 9; biochemistry, 35; biophysics, 14; botany, 19; genetics, 11; medical sciences, 14; microbiology, 18; psychology and anthropology, 10; and zoology, 38.

#### **Developing National Science Policy**

The two operating functions of the Foundation are complemented by the function of developing and encouraging the pursuit of a national science policy on the basis of special studies of science undertaken by the Foundation. The latter, of course, is a long-range program. The increased Federal participation in science makes it necessary that the Government study the various Federal science programs and their relations to the needs of science and the national welfare. To this end the Foundation has already completed preliminary plans for a survey of scientific activities in the United States in the following areas: (a) research programs of the Federal Government; (b) research in industry; (c) research at nonprofit institutions; (d) studies in scientific manpower; (e) studies on the exchange of scientific information; and (f) studies on the current status of scientific progress.

It should be noted that this function of the Foundation is directed to the pursuit of a national science policy. The Foundation's primary function in this area is advisory. In the words of Dr. Chester I. Barnard, chairman of the National Science Board (5):

"Except for certain specified operating func-

tions, the Foundation is essentially an authoritative advisory body, potentially capable of securing factual knowledge and advisory opinion, that makes its advice authentic but not determinative. Whom does it advise? Obviously, first the President and the Congress; but collaterally also, through publication and consultation, other agencies and institutions, public and private, and individuals. The point to these observations is that the Foundation can neither police nor direct activities of other agencies, of academic institutions, of industrial research, or of individual scientists."

#### *Science Studies*

As part of the survey of science activities and as a result of other programs undertaken by the Foundation, several studies are now under way. The Foundation is collecting, on an annual basis, fiscal and budgetary data from all Federal agencies having science programs. The two compilations of these data which have been published (6, 3) provide an insight into trends in Federal expenditures for science. They are useful in analyzing various aspects of the Government's research endeavor, such as the proportions expended between basic, applied, and development research, and the statistical relations of various fields of science. In fiscal year 1952, for example, the Foundation's report shows that of a total of \$338,036,000 in Federal funds for science used at nonprofit institutions \$65,804,000 went to the life sciences. Four agencies administered most of these funds: the Public Health Service, \$18,330,000; the Atomic Energy Commission, \$17,080,000; the Department of Defense, \$14,917,000; and the Department of Agriculture, \$13,109,000.

The Foundation also has under way two broad surveys in the fields of physiology and psychology. These surveys, expected to take about 3 years, are being carried out by the American Physiological Society and the American Psychological Association under contract with the Foundation. Thus, the Foundation is calling upon the scientists themselves and their representative societies to undertake a self-appraisal of the current status of their sciences. The survey undertaken by the American Psychological Association, for example, will include a study of methodology, theory, and applica-

tions of psychology to determine the interrelationships among various branches of psychology and the importance of psychology to other scientific fields. The study will also examine problems in psychological education, manpower, research support, communication, and administration.

#### *Review of Scientific Advances*

Another aspect of the Foundation's program of science studies is the activation of a continuing review of scientific advances in special areas of science. Through scientific conferences and symposiums supported by the Foundation, leading scientists are brought together to exchange information and ideas about their experimental work and their theories. During such conferences, scientists lay the plans for future research. Usually, the subjects discussed are at the frontiers of scientific knowledge, where ideas are in a state of change. During fiscal 1953, the Foundation contributed to the support of three such conferences in the life sciences: one on methods of determination of steroids in blood and urine; another on photosynthesis; and the third on specificity in development.

The Foundation has also taken steps, in cooperation with other Federal agencies, to compile regular lists of Federal grants and contracts for scientific research. These compilations will be useful to all Federal agencies in program planning and in helping to avoid unnecessary duplication. In the fields of psychology and the behavioral sciences, the Foundation now issues quarterly a report of Federal grants and contracts in these areas. In other areas of the life sciences, the Foundation participates in the Biological Sciences Information Exchange.

#### *Scientific Manpower*

In the field of scientific manpower, the Foundation has begun to accumulate data on the characteristics and population of various scientific disciplines. The Foundation is developing a National Register of Scientific and Technical Personnel. The register will be decentralized among several scientific and professional societies so that each society may maintain and use the data for its own needs.

Duplicate cards will be kept by the Foundation. In the life sciences, the American Institute of Biological Sciences and the Federation of American Societies for Experimental Biology are developing comprehensive registers. According to present schedules, all the individual registers will have been established by June 1955. Based upon the data from the registers and the results of other manpower studies, the Foundation expects to publish a series of reports on the manpower characteristics in various fields of science, including professional requirements, training, and employment.

#### *Scientific Information*

Under the scientific information program of the Foundation, grants have been made for the support of important publications in the life sciences. During the last year, emergency support has been given to the publication of *Biological Abstracts*. This valuable information periodical has been faced with increasing publication costs; the Foundation's support, to which several Federal agencies have contributed, is designed to help in reorganizing publication procedures to cope with present needs. The Foundation has also made grants to the University of Chicago for partial support of a monograph titled "Vertebrate Visual System" and to the Torrey Botanical Club for the preparation of a 75-year index to the *Bulletin of the Torrey Botanical Club*.

During fiscal 1953, the Foundation has also provided assistance to American scientists which enabled them to attend important scientific meetings abroad. This program fosters the exchange of scientific information for the mutual benefit of all participating nations and provides United States scientists with direct contact with foreign research activities and personnel. The benefits from attendance at these meetings accrue to this country not only in terms of the increased competence of our scientists, but also in terms of the international goodwill, both scientific and cultural, which is created. The Foundation gave travel assistance to 18 biochemists to attend the Second International Congress of Biochemistry in Paris, France, July 21-27, 1952, and to 15 geneticists to attend the Ninth International

Congress of Genetics in Bellagio, Italy, August 24-31, 1953.

### Summary

The Foundation, as may be seen from the various examples of its activities, is committed to a program of strengthening basic research and education in the life sciences. Both its operating and its staff programs are aimed at these ends. If the Foundation is to be truly significant as an instrument of national policy, it must be responsive to the growth and change in science. Although its study programs are designed to contribute to making it sensitive to the needs of science, it must in the long run depend upon the scientists and their representative societies and the cooperation of other Federal agencies in order to help it fulfill its responsibility: the encouragement of national programs for the progress of scientific research in the United States.

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## Departmental Appointments

**Roswell B. Perkins** took office as Assistant Secretary of Health, Education, and Welfare on March 16, 1954. Mr. Perkins, as one of the two Assistant Secretaries of the Department, will be responsible for continuing analysis and review of the programs operated by the Department and its five major component agencies. He will also assist in the presentation of the Department's legislative program during the 1954 session of the Congress. Mr. Perkins was associated with a New York law firm for 4½ years following his graduation from Harvard Law School and admission to the Massachusetts and New York State bars in 1949, and in 1950 he served as assistant counsel to the Senate Committee to Investigate Organized Crime in Interstate Commerce. He joined the Department of Health, Education, and Welfare in September

1953 as a consultant to the Secretary on legislative matters.

**Victor Christgau** was sworn in as director of the Bureau of Old-Age and Survivors Insurance, Social Security Administration, February 8, 1954. He had served as commissioner of the Minnesota Department of Employment Security since 1939. From 1933 to 1938 he was administrator of the Minnesota Works Progress Administration. He was a member of the United States House of Representatives from 1929 to 1933.

**James Francis Kelly**, formerly director of the budget branch of the Public Housing Administration, has been named budget officer of the Department of Health, Education, and Welfare. He succeeded Marion A. Stephens who retired March 1, 1954.